# PHASE I - INSPECTION REPORT
# NATIONAL DAM SAFETY PROGRAM



# WAR HORSE PROJECT DAMS
## PETROLEUM COUNTY, MONTANA
## MAIN DAM MT - 13 WEST DIKE MT - 3208

**PREPARED FOR:**



**HONORABLE TED SCHWINDEN**

**GOVERNOR, STATE OF MONTANA**

**AND**

**MONTANA STATE DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION**
**OWNER**

**WINNET IRRIGATION COMPANY**
**OPERATOR**

**PREPARED BY:**

**Christian, Spring, Sielbach & Associates**

**Bozeman, Montana**



**Assisted By:**

**Northern Testing Labs, Inc.**

**Great Falls, Montana**

**July 1981**

**Seattle District**

**United States**

**Army Corps of Engineers**

# TABLE OF CONTENTS

## PHOTOS



## PLATES

# EXECUTIVE SUMMARY

Personnel of Christian, Spring, Sielbach & Associates, principal contractor, and Northern Testing Labs. Inc., subcontractors, under a contract with the Montana Department of Natural Resources and Conservation (MDNRC), and with representation from the Winnett Irrigation Company and the MDNRC, inspected Warhorse Main Dam and West Dike on September 3, 1980, under the authority of Public Law 92-367. The project dams and reservoir are located in portions of Sections 27, 28, 29, 33 and 34, T16N, R25E, MPM, offstream of Ford's Creek, tributary to Box Elder Creek in Petroleum County, Montana, approximately 20 miles northwest of Winnett, Montana, by road. The project is a part of the Warhorse National Wildlife Refuge.

## FINDINGS AND EVALUATIONS

The Warhorse Main Dam and West Dike, appurtenances, and diversion system were completed in 1938, with funds provided by the Federal Government and the State Water Conservation Board. Engineering services were provided by the Soil Conservation Service. At that time the project was to furnish water to lands owned by members of the Winnett Irrigation Company. At present the project supplies water to approximately 700 irrigated acres owned by members of the Winnett Irrigation Company. The project is operated and maintained by the Winnett Irrigation Company. The project is listed in the inventory of State Water Conservation Projects, published in March, 1977, by the MDNRC.

Based on a topographic map of the reservoir area prepared by the Soil Conservation Service, the 24-foot-high Warhorse (Main) Dam and the 16-foot-high West Dike commonly impound approximately 21,750 acre-feet of water at the low point in the West Dike, crest elevation 3219.5 feet National Geodetic Vertical Datum (NGVD). Elevations are based on levels taken during the inspection and using assumed elevation 3222.0 feet NGVD at the top of the gate control tower at the Main Dam as a reference elevation. The crest of the Main dam is at elevation 3221.5 feet NGVD as referenced to the assumed benchmark elevation, and the crest of the West Dike is at elevation 3219.5 feet NGVD. On the basis of criteria in the U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size.

The sudden failure of Warhorse Main Dam could cause flooding at a farmstead approximately one and one-half miles downstream. It would damage a county road and bridge crossing and flood agricultural bottomlands in the downstream Box Elder Creek drainage. A sudden breach of the West Dike would cause flooding in a broad flat area prior to flood waters re-entering Ford's Creek. No residences were observed near the dike that would be in danger of flooding due to a breach. The conclusions on probable damage are based on a brief field visit and engineering judgement. No dam breach analysis or routing of a dam breach flood was made for either dam. The project is classified as having a significant (Category 2) downstream hazard potential.

Inspection criteria (Ref. 1) recommend that an intermediate size project with a significant downstream hazard potential be capable of safely handling a flood in the range from one-half to a full probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Based on the assessed downstream hazard potential, we recommend that the project handle a spillway design flood (SDF) of ½ PMF.

Because Warhorse Lake is an offstream storage facility it is largely dependent upon diverted flows from Ford's Creek for filling. Flood volumes that can enter the reservoir during the routing of run-off from a significant storm event is therefore dependent upon the ability of the diversion canal to deliver water to the reservoir for the duration of the flood event considered. There is approximately five-square-miles of peripheral drainage and reservoir surface from which all of the runoff or excess rainfall would enter the reservoir. Assuming no infiltration on the peripheral area the flood volume from this 5-square-mile drainage produced by ½ the PMF is about 3,350 acre-feet. If we further assume that the full diversion capacity is contributing to flood volumes entering the reservoir for a period of 12 hours from beginning of the spillway design flood, an additional 1,500 to 2,000 acre-feet could be taken into reservoir storage during the routing. Since the surcharge storage available is 9,000 acre-feet, it is our judgment that the probability of overtopping the dam by possible flood flows is very remote, provided that maximum normal pool levels are maintained at or near the present crest elevation 3213.5 feet NGVD caused by a breach in the Buffalo Creek supply canal.

The visual inspection of the Main Dam and West Dike embankments revealed serious signs of active wave erosion on the upstream slopes. The reservoir was drawn down to approximate elevation 3205.0 feet NGVD, exposing nearly 50 feet of slope face from water surface to the top of dam. There is very little slope protection to prevent further wave erosion at higher pool levels. Longitudinal cracking of embankment materials was observed intermittently along the main dam crest. Continued deterioration of the upstream dam slopes, which could occur with higher pool levels, would cause localized steepening and could threaten the safety of the dam. As presently operated, with the maximum normal pool at elevation 3213.5 feet NGVD, the West Dike and Main Dam embankments may conform to inspection guidelines for stability of the downstream slopes. The downstream channel at the Main Dam is obstructed near the outlet by sediment, and soil materials have been eroded around and behind the outlet structure wingwalls by flows through the outlet works. The inlet pipe to the gate control tower could not be inspected as it was inundated with water. The gate lift mechanism was not tested, but was reported to be very difficult to operate by the water users present who had recently closed the gate. Art Taylor of the MDNRC also indicated the gate or gate stem was binding and very difficult to operate. Sediment in the bottom of the outlet pipe, outlet basin, and downstream channel are recurring problems caused by water flows eroding the area around the lake inlet during operation of the outlet works.

## RECOMMENDATIONS

Recognizing that possible continued deterioration of the upstream slopes of both the Main Dam and the West Dike embankments may ultimately lead to slope failure; the report recommendations are for engineering

design studies that lead to design and re-construction of dam embankments and upstream slope protection, with factors of safety for stability that ensure long term durability and utility of the project.

Develop, implement and periodically test an emergency warning plan for use in the event of impending dam failure. Remove unconsolidated materials on the upstream face of the Main Dam and West Dike, and replace to the lines, grades, and compacted density as directed by a qualified geotechnical engineer. Provide effective and durable slope protection to protect against anticipated wave erosion. Inspect the outlet pipe upstream from the gate control tower and repair as required. Give consideration to modification of the outlet works lake inlet elevation to protect against siltation problems in the downstream channel. Provide an uncontrolled spillway or outlet in the Main Dam that permanently establishes maximum normal pool levels and has positive discharge characteristics. The spillway should have a discharge capacity at least as large as the capacities of the supply canals. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard, the recommended spillway design flood, and required spillway capability. Modify the project as studies indicate.

Conduct and place on file stability and seepage analyses of the dam embankments. Design modifications to provide factors of safety in anticipated performance that equal or exceed recommended guidelines criteria (Ref. 1) for earth embankment stability. We recommend these anlyses be performed by a qualified geotechnical engineer and be based on; static and seismic loading conditions; in situ strength properties of the embankment, foundation, and abutment materials; and phreatic surface conditions.

Bob B. Gemmell

Bob B. Gemmell
Professional Engineer

# WARHORSE DAMS
# PERTINENT DATA

| | |
|---|---|
| **1. General** | |
| Federal I.D. No. (Main Dam) | MT-13 |
| Federal I.D. No. (West Dike) | MT-3208 |
| Owner | MDNRC |
| Operator | Winnett Irrigation Company |
| Date Constructed | 1911-1938 |
| Purpose | Irrigation and Recreation |
| Project Location (Dams & Reservoir) | Sec. 27, 28, 29, 33, 34, T16N, R25E, MPM.<br>20 miles northwest of Winnett, Mt, by road<br>Latitude 47° 7.2'<br>Longitude 108° 32.2' |
| County, State | Petroleum, Montana |
| Watershed | Off stream of Fords Creek and Buffalo Creek, tributaries of Box Elder Creek. |
| Size Classification | Intermediate |
| Downstream Hazard Potential | |
| Main Dam | Category 2, (Significant) |
| West Dike | Catefory 3, (Low) |
| **2. Reservoir** (Common to Both Dams) | |
| Surface Area at Buffalo Creek Supply Canal Breach, Crest Elevation 3213.5 feet NGVD | 1,300 acres |
| Storage at Breach Crest (maximum normal pool) | 12,750 acre-feet |
| Storage at West Dike Crest Elevation, 3219.5 feet NGVD | 21,750 acre-feet |
| Surcharge Storage | 9,000 acre-feet |
| Drainage Basin; | |
| Above Ford's Creek Diversion | 180 square miles |
| Above Buffalo Creek Diversion | 21.5 square miles |
| Periferal area | 5 square miles |
| **3. Fords Creek Diversion and Supply Canal** | |
| Length | 3.5 to 4.0 miles |
| Estimated Capacity | 1200 c.f.s. |
| **4. "Emergency" Spillway** | |
| Type | Breach in earth bank of Buffalo Creek Supply Canal (1000 feet of unlined canal with a 12-foot bottom width and approx. 1V on 2H side slopes leading from reservoir to breach) |
| Crest Elevation | 3213.5 feet NGVD |
| Breach Width | 24 feet |

# WARHORSE DAMS

## PERTINENT DATA

| | |
|---|---|
| **5. Outlet Works** | |
| Type | 48-inch-diameter RCP with gate control housed in concrete wet well |
| Conduit Length - Intake Length | 45 feet |
| - Discharge Length | 65 feet |
| Capacity with Reservoir at dam crest | 280 cfs. |
| **6. Main Dam Embankment** | |
| Type | Rolled Earth Fill |
| Height | 24 feet |
| Crest Elevation (assumed) | 3221.5 feet NGVD |
| Crest Length | 1950 feet |
| Crest Width | 15 feet |
| Upstream Slope | Variable (1V on 3H average) |
| Downstream Slope | 1V on 2H |
| **7. West Dike** | |
| Type | Rolled Earth Fill |
| Height | 16 feet |
| Crest Elevation (assumed) | 3219.5 feet NGVD |
| Crest Length | 2700 feet |
| Crest Width | 12 feet |
| Upstream Slope | Variable (1V on 3H average) |
| Downstream Slope | 1V on 2H |

# CHAPTER 1
# BACKGROUND

## 1.1 INTRODUCTION

### 1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Warhorse Dam and West Dike owned by the Montana Department of Natural Resources and Conservation.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections on non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May, 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines recommend a two-phase study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety and condition of the dam.
(2) based upon an evaluation of the available data and a visual inspection.
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted.
(4) not intended to include extensive explorations, analysis or to provide detailed alternative corrective recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analysis.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended

only to evalute project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam operators and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership and operation of the dam.

### 1.1.2 Purpose

The purpose of the inspection and evaluation is to identify current conditions of the dam and appurtenances and to determine if emergency measures and/or additional studies, investigations, and analyses are needed, so that corrections can be made in a timely manner by non-federal interests.

### 1.1.3 Inspection

The findings and recommendations in this report were based on a review of incomplete plans concerning certain structural details related to outlet works, visual inspection of the project, and a review of available operation and hydrologic data. No design records were available for review and analysis. Inspection procedures and criteria were those established by the Recommended Guidelines for the Safety Inspection of Dams (Ref. 1).

The inspection was conducted jointly by personnel from Christian, Spring, Sielbach & Associates and Northern Testing Laboratories, Inc., subcontractors. Personnel who participated in the field inspection and contributed to this report were:

CSSA- Bob B. Gemmell, Engineer, Team Leader
Alfred Cunningham, Hydraulics/Hydrology (report only)
Les Crawford, Civil Engineer

NTL- Robert Gillespie, Geotechnical Engineer (report only)
Bill Henning, Geologist
Gary Quinn, Geotechnical Engineer

MDNRC- Art Taylor, MDNRC Dam Safety Engineer

Other personnel present and participating in the field inspection include:

Winnett Irrigation Company - Dave Hale
Gene Stewart

This report has been reviewed by: Montana Department of Natural Resources and Conservation and the Winnett Irragation Company and their written comments are enclosed in Appendix A.

## 1.2 DESCRIPTION OF PROJECT

### 1.1.2 General

#### a. Location and Owner

The Warhorse Project, sometimes called the Winnett Irrigation Project, is located off-stream of Ford's Creek and Buffalo Creek principally in Sections 27, 28, 29 and 34, Township 16 North, Range 25 East, MPM in Petroleum County, Montana, about 8 miles north of Tiegen, Montana. (Plate 1) The offstream reservoir impoundment is formed by a Main Dam on the east end of the reservoir and an earth dike known as the West Dike on the west end. A four mile long diversion channel from Ford's Creek enters the reservoir from the west. The outlet works is located in the Main Dam embankment, and an uncontrolled breach in the diversion canal from Buffalo Creek serves as a control for normal reservoir levels and an "emergency" spillway for the project. Because of the breach little water would enter the reservoir from Buffalo Creek. The Warhorse Main Dam with Federal Identification Number MT-13 is located in the NE 1/4 of Section 34, and the Warhorse West Dike with Federal I.D. Number MT-3208 is located in NW 1/4 of Section 29. (Plate 2) The Main dam and the West Dike are listed as having a Significant (Category 2) and Low (Category 3) downstream hazard potential respectively.

The dams are owned by the State of Montana Department of Natural Resources and Conservation (MDNRC) and operated by the Winnett Irrigation Company Group. The original project was planned to supply irrigation water to lands owned by the Winnett Irrigation Company. The project has been plagued by water shortages and maintenance problems in the distribution system. At present the project reportedly serves approximately 700 irrigated acres. The lake is given a considerable amount of recreational use and is part of the Warhorse National Wildlife Refuge.

The following is taken from "State Water Conservation Projects," Montana Department of Natural Resources and Conservation, March, 1977. (Ref. 5)

> "The Warhorse Project, sometimes called the Winnett Irrigation Project, is located to the northwest of Winnett in Petroleum County. It includes an offstream storage reservoir with a capacity of 19,250 acre-feet, a diversion canal from Fords Creek, a distribution canal, an outlet canal, and an additional small reservoir known as Little Bear Lake. Construction, financed with federal and SWCB funds, was completed in 1938.
>
> Maintenance of the distribution canal became excessively expensive, and that portion of the project was abandoned; it has now washed out below Buffalo Creek. Although there are only two users of project water, there is substantial local interest in repairing the project and using the stored water. The lake is given a considerable amount of recreational use and is part of the Warhorse National Wildlife Refuge.
>
> The Department in 1973 considered releasing the Warhorse Project to Winnett Irrigation Company, the water user group who originally used the project. The dam was inspected and recommendations for its repair were made. Before making any decisions regarding the proposal to release the project, the Department asked for public input

concerning the future use of the project. Alternative proposals for its use were received from the Bureau of Land Management, U.S. Sport Fisheries and Wildlife Service, and the Winnett Irrigation Company. The federal agencies proposed to operate the facilities primarily for fisheries and wildlife, and the Winnett Irrigation Company proposed to use them primarily for irrigation. There was public support for each of the proposals. Investigations were made to determine whether an operation plan could be developed whereby wildlife and irrigation uses could both be enhanced. It was determined that both cases could benefit during some years, but that in dry years irrigation would dry up the reservoir, thus reducing wildlife benefits. Since the project deed gives the Winnett Irrigation Company first priority of ownership, the decision was made to release the project to the Company, provided it agrees to make the necessary repairs. The irrigators agreed to try to cooperate with wildlife interests as much as possible.

It is expected that the project will be released as soon as the necessary administrative steps can be taken."

Water Measurement

The project has no measuring devices.

b. Description of Dam and Appurtenances

The Warhorse Main Dam and West Dike are earth fills constructed of locally available borrow materials. The Main Dam embankment has a height of 24.0 feet from downstream toe to dam crest. (Plate 4) The West Dike has a height of 16 feet from downstream toe to dam crest. (Plate 3) All elevations in this report are based on an assumed elevation 3222.0 feet NGVD at the top of concrete gate control tower. The low point in the Main Dam Crest is at 3221.5 feet NGVD. The West Dike crest is generally at elevation 3220.5 feet NGVD with a low elevation of 3219.5 feet NGVD. This is the lowest point in the reservoir boundary and is therefore used as dam crest throughout this report. The estimated storage capacity at dam crest is 21,750 acre-feet.

The "emergency" spillway is a man made breach in the downstream bank of the Diversion Canal (Plate 6) which enters the reservoir from Buffalo Creek at a point just upstream from the right abutment of the Main Dam. The breach serves to control maximum water elevations in the reservoir at approximately 3213.5 feet NGVD. Surcharge storage between the emergency spillway crest and top of dam crest is approximately 9000 acre-feet. The reservoir peripheral drainage area and reservoir surface area is estimated to be 5 square miles and the drainage area above the diversion channel from Ford's Creek is estimated to be 21.5 square miles. The drainage area above the diversion structure in Ford Creek is estimated to be 180 square miles.

The diversion from Ford's Creek has a very flat gradient. The design capacity is 1200 c.f.s., however, a new bridge on the county road crossing the diversion on the west side of the lake may be obstructing channel capacity. There are no records of maximum flow rates in the diversion channel.

The outlet works is a 48 inch-diameter reinforced concrete pipe approximately 110 feet long located at the base of the main dam. A 48-inch-diameter gate located in a concrete wet well on the reservoir side of the dam crest controls the outlet works discharge.

c. Hazard Potential

Based on visual reconnaissance and engineering judgement, a sudden breach of Warhorse dam would flood and damage a single residence approximately one and one-half miles downstream and would damage a county road. It would flood bottom lands along Buffalo Creek and Box Elder Creek downstream. A sudden breach of the West Dike would cause flooding in a broad, flat area prior to flood waters re-entering Ford's Creek. On the basis of this information and in accordance with recommended guidelines, (Ref. 1) Warhorse Dam(s) project size is intermediate and the downstream hazard potential is significant (Category 2). No dam breach analysis or routing of a dam breach flood was made.

## 1.2.2 Regional Geology - Warhorse Dam and West Dike

The dam and watershed area are underlain by sedimentary rocks of Cretaceous age. The area is characterized by gently rolling plains with many undrained depressions.

The Colorado Group underlies the site and surrounding area and consists of the lower Cretaceous Blackleaf Formation and the upper Cretaceous Marias River Formation. An unconformity separates the two formations. The total thickness of the group is approximately 1800 to 2000 feet. Deposition of the Colorado Group was the result of numerous transgressions and regressions of a large inland sea, extending from the Gulf of Mexico to the Arctic Ocean, and covering all of the eastern and central parts of the state. "The normal strata of Late Cretaceous age in the plains of Montana are divided into three major divisions: (1) The Colorado Group of formations, developed during the first great wide spread advance of the sea; (2) the Montana Group, about 1500 feet thick, developed during the advances and recessions of the sea; and (3) the Hell Creek Formation, about 700 feet thick, a land-laid series of sediments developed after the final and complete retreat of the sea." (Ref. 2)

During the Tertiary, these units were faulted and broadly folded, producing the structure seen in the area today.

The Blackleaf Formation consists of very black to gray shale and light, fine-grained quartz sandstone beds. Many bentonite, iron-concretion, and pebble lenses are interbedded.

The Marias River Formation is predominantly dark-gray fissile shale containing many thin beds of dark-gray calcareous concretions and some thin sandstone lenses. The dam and watershed areas are located on the upper part of the Marias River Formation.

## 1.2.3 Seismicity

The site lies in Seismic Zone 1, a zone of generally minor seismic risk. In accordance with Corps of Engineers recommended guidelines, a seismic coefficient of 0.05 is appropriate.

Preliminary seismic mapping by Algermission and Perkins indicates there is a 90 percent probability that the horizontal acceleration in rock will not exceed 0.04g in a given 50-year period.

### 1.2.4 Site Geology

Warhorse Dam is located in a broad, open valley. Shale of the upper Cretaceous Colorado Group, Marias River Formation underlies the site and surrounding area. The dam abutments and foundation rest on this shale. A thin veneer of fluvially reworked shale and some silt and sand can be seen in the center of the downstream channel. The valley has extensive alkali deposits, the result of leaching of the gypsum in the shale by rain and groundwater and redeposition on the valley sides and floor.

### 1.2.5 Design and Construction History

In early 1911 the Winnett Irrigation Company (WIC) was incorporated for $100,000 by 37 land owners whose 10,850 acres were susceptible to irrigation. A four mile long, 6 foot deep canal with a metal flume section was built to carry water from Ford's Creek to a large flat saddle. A dike was built on the west end and a somewhat larger earth dam was built on the east end of the saddle creating Warhorse Reservoir. Cost of construction was about $145,000. 6,500 acres were irrigated with good results during several years of higher than average rainfall.

In subsequent years normal rainfall did not provide enough water to be diverted down the channel to fill the reservoir. The channel was frequently run at bank level in the spring causing many breaches and the eventual failure of the metal flume. Crop losses were astronomical.

In December of 1934, ownership for the project was transferred to the Montana State Water Conservation Board (MSWCB) by Quit Claim Deed with the understanding the project would be rehabilitated. During the mid-thirties a CCC camp was operating nearby under the direction of the USDA Soil Conservation Service. About $165,000 was spent on Warhorse repairs with the MSWCB providing materials and equipment.

Project modification included construction of a new canal and building a 12-foot-high earth diversion dam on Ford's Creek. A reinforced concrete intake structure with two 12 X 6 foot tainter gates controlled intake flows to the canal. A 24-inch diameter CMP with a 24-inch square gate controlled bypass flows to Ford's Creek.

MSWCB files indicate an estimated 19,250 acre feet of storage would be available for use on 5,000 acres of land. The drainage basin of Ford's Creek above the diversion dam is about 180 square miles, ¼ of which is in the Judith Mountains at elevations between 4,000 and 6,000 feet NGVD.

In 1947 a Water Marketing Contract was signed between MSWCB and WIC. Fourteen (14) WIC members contracted for 2,300 acre-feet at 65¢/af for the next 30 years. Water supply was to be increased in increments specified in the contract.

The last MSWCB record entries are in 1971 and are regarding the damaged outlet controls and a final request for WIC's delinquent 1969,

1970, and 1971 annual reports. On July 30, 1970 the WIC was "certified to the (State) Attorney General for involuntary dissolution . . . for failure to file its delinquent annual reports and for not appointing and maintaining a registered agent and registered office." As of October 4, 1971, no action has been taken. (Letter from Secretary of State Murray to MSWCB with Request to Forward to WIC.)

As current owner, MDNRC has made project inspections every 2 years since 1975. In 1975 the outlet conduit and channel was becoming over-grown. In addition, erosion was observed at the county road/supply canal crossing as well as the West dam embankment. The recommendations were made to clean and repair the outlet conduit and to maintain adequate freeboard. Reservoir storage was estimated at 19,000 acre-feet. In 1977 erosion was noted around the headwalls of the diversion structure. A larger headwall was recommended. Conditions observed in 1975 were still apparent and a recommendation to replace the county road crossing was made. Reservoir storage was not estimated.

On May 2, 1979 an inspection of Warhorse Dam observed about 18,000 acre-feet of storage. The county would finish the new bridge at the supply canal by mid-summer. The outlet conduit is still deteriorating. Although no seepage was observed several cracks 1/4-inch wide and 6-inch deep were noted in the conduit. The operating controls were binding and the gate was difficult to close. Some water was leaking around the gate. The upstream area, around the outlet works was in need of more riprap and fill. No mention of the seriousness of the needed fill was recorded.

On Sunday, May 13, 1979, large wind generated waves severely eroded the upstream face near the outlet works. (Photos 15 & 16) The combination of higher than normal reservoir levels and very high winds caused the waves to break above the riprap protection. MDNRC personnel and several local residents excavated a breach in the supply canal from Buffalo Creek and used a paddle scraper and dozer to implement emergency repairs. A temporary breakwater was constructed using old telephone poles to better protect the repaired area. A metal arch pipe was installed through the bank of the Ford's Creek supply canal to further lower the reservoir (This pipe has since been removed). The final MDNRC report that was available recommended rebuilding the embankment with more suitable materials and construction methods, add riprap to the entire upstream face, construct a permanent spillway in the supply canal from Buffalo Creek, check the outlet conduit for damage. Current embankment conditions are covered in sections 2.3 and 3.1.5-7.

# CHAPTER 2

# INSPECTION AND RECORDS EVALUATION

## 2.1 HYDRAULICS AND STRUCTURES

### 2.1.1 Outlet Works

The outlet works for Warhorse Dam(s) is located in the Main Dam near the center of the embankment (Plate 5). A reinforced concrete gate tower located upstream from the dam crest houses a 48-inch-diameter gate and gate lift mechanism with the top of the tower at elevation 3222.0 feet serving as a gate hoist base. (Photo 10) The control tower functions as a wet well with the gate on the downstream side. A 48-inch-diameter reinforced concrete pipe extends about 45 feet upstream to the lake inlet and about 65 feet downstream to the outlet structure from the gate tower. (Photo 11) The maximum discharge with the lake level at dam crest elevation 3219.5 feet is estimated to be 280 c.f.s., and discharge with lake level at emergency spillway crest (maximum normal pool elevation) is estimated to be 230 c.f.s. The outlet discharge rating was developed assuming a Manning's "n" = 0.015 for aged concrete pipe under full pipe flow conditions.

At the time of inspection, the inlet was underwater. However, the water users present recalled that the channel from the lake to the inlet conduit was filled with silt. The outlet conduit downstream from the gate was inspected and appeared to be in fair condition. The inside of the pipe appeared to have been recently patched with a plastic mortar. The plastic mortar has cracked in several places. There was approximately one foot of sediment in the bottom of the pipe near the outlet, which had apparently deposited as the lake was lowered for this inspection. The bottom of the outlet basin was filled with sediment and the downstream channel showed signs of sediment deposits. Exposed concrete in the outlet basin was in generally poor condition due to cracking and spalling (Photo 11). The concrete in the gate control tower appeared to be in fair condition. Repairs were made in 1971, when exposed concrete deterioration due to weathering had progressed to point of exposure of steel reinforcement. The gate lift mechanism was not tested, however, the water users present stated that the lift mechanism was extremely hard to operate and appeared to be binding. This condition was reported in the May 2, 1979 inspection report by the Montana Department of Natural Resources and Conservation. The binding of the gate and cracking of the outlet conduit may be the result of settlement.

### 2.1.2 Emergency Spillway

The "emergency" spillway for Warhorse dams is a breach in the downstream bank of the Buffalo Creek supply canal located approximately one-third mile upstream from the point where the supply canal enters the lake. The breach was installed as an emergency measure in May, 1979, to control maximum lake levels so that emergency repairs to the wave eroded upstream face of the Main Dam embankment could be initiated. The breach in the bank is approximately 24 feet wide at the crest elevation 3213.5 feet NGVD. (Plate 6 and Photo 13) Crest elevation for the breach was obtained from a water line on the gate control tower identified by Dave Hale as the elevation at which flow starts through the supply canal breach. The inlet

channel from the lake to the breach has a 12-foot bottom width and variable side slopes of nearly 1V on 2H. (Photo 12) Because the approach channel from the reservoir "inlet" is on a long slightly adverse grade, the maximum flows that could be discharged through the breach is dependent upon the capacity of the approach channel. During the routing of an extreme flood event flow could be expected to be coming from the Buffalo Creek diversion toward the reservoir. This flow would severely restrict flow that could be generated from reservoir head toward the breach. The breach would function as an "emergency" spillway when reservoir levels are sufficient to cause flow toward the breach. No other uncontrolled spillway exists in the project. The outfall from the "emergency" spillway is a broad, sloping hillside. (Photo 14) Vegetation on the spillway exit is characterized as "sparse." Soil materials at the breach crest and in the exit channel area appear to be highly erodible. However, because of its location, such erosion as may be caused by prolonged flows through the breach would not endanger the dam embankment. Because of the questionable viability in routing the spillway design flood, no discharge rating curve was developed for the breach.

### 2.1.3 Freeboard

Prior to the May, 1979 emergency, when large wind generated waves severely eroded the upstream face of the Main Dam (Photos 15 & 16) and reportedly were splashing over the dam crest, maximum lake levels were apparently uncontrolled, as no spillway existed at the time. The crest elevation of the breach in the Buffalo Creek supply canal is at elevation 3213.5 feet NGVD, approximately 6 feet below dam crest. The fetch length for a north-west wind is about 2½ miles. The estimated wave height that would be generated by a 50 mile per hour wind is given by the equation $H = 3.92 \times 10^{-2} F^{0.47}$ where H = wave height and F = effective fetch length in feet (Ref. 7). With a fetch length of 12,000 feet the estimated wave height is 3.22 feet. With the lake level control provided by the breach, it is unlikely that wave runup would overtop the dam embankments. At the time of inspection the reservoir level was at elevation 3205.7 feet NGVD, about 16 feet below the dam crest. However, there is evidence of severe wave erosion on the upstream face of both the Main Dam and the West Dike. (Photos 5, 6, & 10) Because of the uncertainty of the volume of diversion flows that would enter the reservoir during the routing of the SDF, reservoir levels that may be attained under existing conditions is difficult to predict. However, preliminary routings (para. 2.2.4) indicate the dam would not be overtopped.

## 2.2 HYDROLOGY

### 2.2.1 Physiography and Climatology

The Warhorse Dam and Reservoir are located in Section 34, Township 16 North, Range 25 East in the Northwest corner of Petroleum County near Winnett, Montana, (Latitude 47° 7.2', Longitude 108° 32.2'). Elevation of top of dam is 3219.5 feet NGVD. The primary purpose of the reservoir is to regulate flow in the Winnett Irrigation Company canal which drains eastward and eventually flows into Box Elder Creek. The reservoir site is located in what is commonly known as the Great Plains of Montana, which is characterizied by flat, treeless expanses, and large, gently rolling hills.

The climate in this region of Montana is commonly considered "Continental" and therefore is typical for the interior of a large land area. Weather is highly variable with rapid changes brought on by the invasion of large air masses from the Gulf of Mexico, the Southwest, the North Pacific Ocean, and the Polar regions. Montana is in the Westerly wind belt throughout the year with the result that much of its weather comes from the Gulf of Alaska. Annual temperature variation at the Warhorse reservoir site is extreme with summer highs in the nineties and winter lows of minus 30°F. The average "freeze-free" season for the Warhorse location is about 120 days ranging from mid-May through mid-September. Average annual precipitation is about 16.5 inches with heavy amounts occurring from summer thunderstorms. Annual average lake evaporation is about 45 inches. (Ref. 4)

2.2.2 Reservoir Storage

The reservoir has a water storage capacity of 12,750 acre-feet at maximum normal pool elevation 3213.5 feet NGVD and approximately 21,750 acre-feet at West Dike dam crest, elevation 3219.5 feet NGVD. Approximately 9,000 acre-feet of surcharge storage is available in the reservoir between the "emergency" spillway crest and the dam crest.

2.2.3 Estimated Spillway Design Flood

The recommended spillway design flood (SDF) for an intermediate sized project with a significant downstream hazard potential is a flood equal to 1/2 the PMF to the full PMF. Because of the remote location of the project, and the relatively minor potential for downstream damages, ½ the PMF is chosen as the SDF. The probable maximum flood (PMF) is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. There is at this time no evidence of extensive developments proposed downstream that would change the hazard classification.

Because Warhorse reservoir is largely dependent upon diversion from Ford's Creek for filling, the maximum capacity of the diversion structure headworks leading to the diversion canal, and the maximum capacity of the diversion canal is significant in estimating peak flows that could possibly enter the reservoir during the routing of a significant flood event.

The diversion headworks consists of a dam across Ford's Creek with an earth emergency spillway on the west abutment. A 24-inch-diameter gated pipe extends through the diversion dam and releases flows downstream in Ford's Creek. The diversion structure leading to the canal consists of two 6 X 12 foot tainter gates located just upstream of the east abutment of the dam which control flows into the Diversion Canal. At the time of inspection, one of the tainter gates was in closed position and is considered inoperable (Photo 1).

The diversion canal cross section is formed by both excavation and embankment on the downstream side of the excavation. The embankment is six to eight feet in height for most of the length of the diversion. The maximum canal capacity is determined by the point of embankment overtop and insufficient data is available to accurately determine this figure. However, design reports and construction drawings indicate that the diversion canal has a carrying capacity of approximately 1,200 c.f.s.

The 180-square-mile drainage area above the Ford's Creek diversion is extensively developed with water spreading systems, irrigation diversions, and surface storage facilities. There are no continuous flow records available for Ford's Creek. There is approximately 21.5-square-miles of drainage area above the diversion canal that could be intercepted by the canal and diverted to the reservoir. There is approximately 5-square-miles of peripheral drainage area including the reservoir surface area from which runoff would enter directly into the reservoir.

In accordance with the "Interim All-Season Probable Maximum Precipitation Estimates, Missouri River Drainage West of the 105th Meridian (Ref. 1), the probable maximum precipitation (PMP) for the 24-hour, 10-square-mile all season storm event is about 23 inches. The 72-hour PMP is estimated to be about 26.5 inches. Thus, a flood of one-half the full PMF would be equal to ½ PMF hydrograph ordinates generated by the 72-hour PMP. If we assume zero infiltration, the total flood volume is ½ PMP or 13.25 inches from the drainage area contributing directly to the reservoir.

2.2.4 Flood Routing

The routing of extreme flood events to this offstream storage facility is very complex and does not warrant development of synthetic flood hydrographs in assessing the project's storage and discharge capabilities. Factor's affecting the amount (volume) of water that could enter the reservoir during the routing of a significant flood event such as ½ PMF are:

1. The total volume in time delivered by the Ford's Creek diversion channel.
2. The total volume in time delivered by the Buffalo Creek diversion canal.
3. The total volume in time that can enter directly into the reservoir from the periphery drainage including the reservoir surface.

It is our judgment that the Ford's Creek diversion and the diversion channel would be washed out in a very few hours after the onset of the SDF.

Therefore the following scenario is selected as a possible test of storage and/or discharge capacity of Warhorse Project.

1. Full channel flow could enter the reservoir from the Ford's Creek diversion for a period of 12 to 14 hours after the onset of the spillway design flood prior to breach failure of the diversion channel. Thereafter flows would be minimal.
2. Because of the breach in the Buffalo Creek supply canal., no flows would enter from this source.
3. Assuming zero infiltration the volume of water that could enter directly from the 5-square-mile periphery drainage is 3,530 acre-feet (13.25 X 640 X 5 X 1/12).
4. No out flows will occur from the reservoir to the breach in the Buffalo Creek supply canal due to competing flow from the Buffalo Creek diversion.

The total estimated volume that could enter the reservoir during a flood event equal to ½ the PMF is approximately 1,850 acre-feet from the

Ford's Creek diversion plus 3,530 acre-feet from the peripheral drainage area contributing directly to the reservoir. Surcharge storage between the present maximum normal pool elevation 3213.5 feet NGVD and dam crest elevation 3219.5 feet NGVD is estimated to be 9,000 acre-feet. It is obvious that the 5,380 acre-feet of flood volume resulting from a flood equal to ½ the PMF can be contained without "emergency" spillway flow.

## 2.3 GEOTECHNICAL EVALUATION

Warhorse Dam was constructed to close off a saddle between Ford's Creek and Buffalo Creek, both tributaries to Box Elder Creek in the Musselshell River Watershed. A dike closes a small drainageway at the northwest corner of the reservoir to allow development of the desired maximum pool elevation. To our knowledge, there are no records of foundation investigations, nor stability analyses for the dam. Project records indicate the embankment is constructed by locally available homogeneous material.

### 2.3.1 Dam Embankment

#### Main Dam

The dam, located at the east end of the reservoir, is approximately 1,950 feet in length and has a maximum height of about 24 feet above existing ground. The crest width is 15 feet. (Plate 4) At the time of inspection, the water level in the reservoir was approximately 16 feet below the dam crest.

The upstream slope is extremely variable due to extensive wave erosion. It appears that the original slope was probably on the order of 1V on 3H. The upstream slope north of the intake structure has been eroded vertically for a depth of 5 feet along much of this length (Photo 10). The embankment thus exposed appears to consist of a homogeneous clayey silt core surrounded by a thin shell of sand, gravel, cobbles and boulders. South of the outlet works, loose, clayey silt fill has been placed as a stop-gap reshaping of the slope. Riprap consists of a mixture of sandstone and volcanic boulders varying from 1 to 3 feet in diameter. No graded filter bedding was apparent. The riprap has subsided with the loss of ground along the slope and offers little protection for the exposed slope.

The profile along the dam crest has numerous irregularities associated in part with the longitudinal cracking observed over much of the crest length (Photo 8). This cracking may be related to the high plasticity (high volume change potential) of embankment soils. These soils, examined and sampled along the surface of the dam crest, were clayey silts and weathered shale. Index testing on two random samples indicated Unified System Classifications of CH and CL. The crest of the dam does not have a surface maintained for vehicular traffic; some minor rutting has resulted.

The downstream slope does not appear cracked or settled. Occasional areas along the slope deviated from the standard 1V on 2H. Examination of these areas did not indicate evidence of movement. The slope has a medium dense cover of sagebrush, thistles, and other weeds. Only minor signs of animal traffic and burrowing were observed. No seepage was observed on the slope.

Extensive areas of saline seep were noted immediately downstream of the embankment (Photo 9). Such deposits were typical in the valley both up and downstream of the dam. The downstream channel is obstructed by silt deposits. Erosion around the lake inlet to the outlet works is probably the source of this material.

The abutment contacts did not show differential movement, cracking, or erosion.

There are no records or indications of embankment performance monitoring or of the installation of piezometers for either embankment.

West Dike

The dike is approximately 2700 feet in length, has a maximum height of 16 feet, and a crest width of 12 feet. (Plate 3) At the time of inspection, the pool elevation was about 14 feet below the dike crest.

The dike crest was not cracked, settled, or misaligned. Some minor vehicular traffic damage was observed.

The upstream slope is deeply eroded due to wave action (Photos 5 and 6). This erosion has backcut the silt-clay slope to the vertical in the upper 3 feet of the embankment for a distance greater than 500 feet along the dike. No slope protection was observed.

The downstream slope was not cracked or otherwise irregular, although some minor rilling was noted on the 2H to 1V slopes. Vegetative cover was sparse. (Photo 4) No seepage was observed or indicated along the slope.

The abutment contacts appeared sound.

2.3.2. Foundation Conditions, Seepage and Drainage

The weathered shale deposits observed in the abutment areas are probably covered in the valley floor by a thin silt-clay overburden derived from these shales. The shale bedrock surface results in the poor drainage and saline seep conditions observed in the valley.

Seepage was not observed along the slopes or abutment contacts of either the dam or dike under the low pool conditions. The origination of saline seepage indicated immediately downstream of the dam could not be ascertained, although this condition is prevalent in drainages throughout the area. It is unknown, but doubtful, that any internal drainage system exists.

Upstream erosion along the dam has removed approximately 3 to 6 feet of embankment material from around the turnstile housing and platform of the intake structure. This loss of ground does not appear to have caused settling, tilting, or other surficial damage to the structure (Photo 10).

The channel is being backcut at the outlet with an accompanying loss of fill material behind the wingwalls at the outlet.

### 2.3.3 Stability

No stability analysis has been made to our knowledge, nor is sufficient data available to make them, however, except for erosion on the upstream slopes of both dams, neither the Main Dam or West Dike exhibit serious signs of instability in the downstream slope.

## 2.4 PROJECT OPERATIONS AND MAINTENANCE

Warhorse Dam is owned by the Montana Department of Natural Resources and Conservation and operated by the Winnett Irrigation Company. There is no formal operation and maintenance program for the project. Information on operations and maintenance was obtained through discussions with Art Taylor and Glen MacDonald of MDNRC and with Dave Hale and Gene Stewart of the water users association. Critical maintenance or repairs are made as the need arises.

### 2.4.1 Dam

Maintenance of the dam is performed by Winnett Irrigation Company as required. A MDNRC Dam Safety Inspector visits the site at least every two years or as conditions warrant.

### 2.4.2 Reservoir

The primary use of the reservoir is irrigation. The reservoir level can be regulated by the gates both on the diversion dam and the outlet works. According to MSWCB records, insufficient water supply for irrigation is the most recurring problem. Normal operation is with the inflow gates at the Ford's Creek diversion structure to the supply canal open year-round and irrigation flows are released as needed. At present one diversion gate at Ford's Creek is inoperable and in a closed position.

### 2.4.3. Warning Plan

There is no formal warning plan for use in the event of impending dam distress. Nearby water users visit the dam frequently during the irrigation season and would probably notice potentially dangerous conditions as they did in 1979.

# CHAPTER 3

# FINDINGS AND RECOMMENDATIONS

## 3.1 FINDINGS

### 3.1.1 Size, Hazard Classification, and Safety Evaluation

The Warhorse Main dam is 24-feet in height and the West Dike is 16-feet in height. The reservoir formed by the dams impounds approximately 21,750 acre-feet at the low point in the West Dike crest elevation of 3219.5 feet NGVD. The Main Dam crest is at elevation 3221.5 feet NGVD. The flood plains downstream from both dams are broad and flat, and should provide for rapid dissipation of breach heads, however the large volume of water released would carry many miles downstream prior to attenuation. A single farm dwelling downstream from the Main dam could be affected by a sudden failure of the dam. A county road and bottomlands in the Box Elder Creek drainage would be flooded. No dam breach analysis or flood routing of a dam breach hydrograph was made. In accordance with inspection guidelines the project size is intermediate and, based on our visual inspection and judgment, the downstream hazard potential rating is significant (Category 2). The recommended spillway design flood (SDF) for this project is 1/2 PMF.

In the spring of 1979 lake levels were allowed to rise to within 3 to 4 feet of the dam crest. In May, 1979 high winds caused waves reported to be three to four feet high on the lake. These waves severely eroded the upstream face of the main dam. Emergency repairs were made by the water users and the MDNRC. Subsequently, a breach was made in the low bank of the Buffalo Creek supply canal to aid in lowering lake levels. With this breach acting as a lake level control it is anticipated that the maximum normal operating lake level will not exceed elevation 3213.5 feet NGVD, approximately 6 feet below the crest of the west dam. Reconnaissance level investigations indicate that the surcharge storage is adequate to handle the flood volumes that would enter the offstream storage from the recommended spillway design flood, which is ½ PMF. Overtopping the dam is considered very unlikely. Flood peaks that could enter the reservoir would be diminished by overflow and failure of the diversion channels.

The Main Dam embankment exhibited cracking and both embankments displayed severe wave damage on the upstream slopes. Slope protection is inadequate or non-existent on both the main dam and west dike. The potential for continued undercutting due to wave erosion, along with cracking at the dam crest threatens stability of the upstream slopes.

### 3.1.2 Outlet Works

The inlet pipe from the reservoir to the gate control tower was under water and could not be inspected. Concrete in the gate control tower, which was repaired in 1971 appeared to be in fair condition. The gate lift mechanism is very difficult to operate, and reportedly has been for several years. The outlet pipe from the control tower to the outlet box appeared to be in fair condition, although some minor cracking of the plastic mortar lining which covers the entire length of the outlet works was noted, and may be the result of continuing settlement of the outlet works. Exposed

concrete in the outlet basin is in generally poor condition due to cracking and spalling.

### 3.1.3 Emergency Spillway

The "emergency" spillway for this project is a breach in the low bank of the supply canal from Buffalo Creek. The breach was installed as an emergency measure in May. 1979, to control reservoir levels so that emergency repairs on the wave-eroded upstream slope of the embankment could be accomplished.

The breach will function as a primary spillway when reservoir elevations provide sufficent head to overcome competing heads caused by flows toward the reservoir in the Buffalo creek supply canal. Because the breach crest is subject to erosion, and its function as an "emergency" spillway is questionable in routing extreme flood events, it is our opinion that a more positive means should be installed in the project to control selected maximum normal reservoir elevation, and to bypass excess flood flows in a safe manner.

### 3.1.4 Reservoir Storage and Discharge Capacity

The reservoir has a storage capacity of 12,750 acre-feet at the crest of the breach in the Buffalo Creek supply canal, and approximately 21,750 acre-feet at low point on the West Dike crest, elevation 3219.5 feet NGVD. Engineering data supplied for Warhorse Dam lists the storage at 19,250 acre-feet, however the depth of water associated with this storage is undetermined. The surcharge storage available between the dam crest and the "emergency" spillway crest is approximately 9,000 acre-feet. The uncontrolled breach in the Buffalo Creek supply canal serves to stablize normal lake levels at 3213.5 feet NGVD.

Routing of the recommended spillway design flood (SDF) shows that the reservoir has sufficient surcharge storage to safely contain the SDF flood volume without overtopping the embankment dams. However, an uncontrolled outlet or spillway with a permanent crest and positive discharge characteristics at given lake levels would be desirable for reservoir management purposes. Any changes in project configuration would require further hydrologic and hydraulic routing studies.

### 3.1.5 Dam Embankments

#### Main Dam

Longitudinal cracking was observed intermittently along the dam crest. The continuity and depth of this cracking could not be determined, but could be several feet deep.

The upstream slopes, have been severely damaged by wave erosion and there is no slope protection to prevent future wave erosion during higher pool levels. This potential for continued wave undercutting, resulting in vertical slopes threatens upstream slope stability.

No seepage was observed under the low pool condition at the time of inspection. Continued erosion of the upstream slope could result in shorter seepage paths and steeper exit gradients on the downstream slope.

The downstream channel is obstructed near the outlet by silt, apparently deposited as a consequence of upstream slope erosion around the inlet to outlet pipe. The channel backcutting is also causing a loss of soil material from behind the outlet structure wingwalls.

West Dike

The reservoir side of the dike is severely eroded for approximately 500 feet. No slope protection exists along this length.

### 3.1.6 Stability

Downstream slope stability may conform to the guidelines under normal operating conditions i.e. with 6 feet between normal maximum pool and low point on dam crest, and a 50 foot wide embankment at that elevation which may have a very low permeability. However, should the project store water above the current maximum normal level, stability may be questionable and should be evaluated by an engineer experienced in dam design and construction.

### 3.1.7 Operations and Maintenance

The project in general is in a deteriorated condition. The emergency repairs made in 1979 by the water users and the MDNRC provided a stop gap that prevented almost certain failure if left unattended. Fill materials placed on the upstream slope during the emergency was uncompacted except by equipment travel. The dam embankments are subject to wave erosion and undercutting on the upstream face. The uncontrolled breach in the supply channel from Buffalo Creek serves to control maximum water surface elevation in the reservoir at approximately six feet below dam crest. No formal operations and maintenance plan as such exists. Report recommendations are directed at needs for extensive rehabilitation that will insure that long term durability and safety of Warhorse Dam and the West Dike.

## 3.2 RECOMMENDATIONS

Due to surcharge storage between the uncontrolled breach in the Buffalo Creek supply canal and the dam crest, the present project is capable of handling large inflows of long duration without overtopping. The major intent of report recommendations is to maintain or improve project embankment stability and safety.

1. Remove and replace uncompacted materials on the upstream face of the Main Dam and West Dike and restore eroded slope materials to a uniform line and grade as directed by a qualified geotechnical engineer. Compact soil materials to a specified density to form a base for riprap. Provide durable and effective wave erosion protection (riprap) to anticipated wave heights on the upstream slopes of both the Main Dam and West Dike.

2. Inspect the outlet pipe upstream from the gate control tower and repair as required.

3. Repair control gate and/or lift mechanism to prevent binding and to ensure optimum operation afforded by gear-ratio in the lift mechanism.

4. Consider raising the crest elevation of the intake structure to the gated outlet works to prevent silt being discharged downstream as lake levels are lowered.

5. Consider providing a spillway with more positive discharge characteristics and a more permanent crest to control maximum normal lake levels. The spillway should have a capacity at least as large as the capacity of the supply canals. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and to provide a basis for change in project configuration if contemplated.

6. Develop and implement an operations and maintenance plan for the project which involves periodic inspections by the dam owners and the operators.

7. Develop, implement, and periodically test an emergency warning plan for use in the event of impending dam distress.

# REFERENCES


1. U.S. Army Corps of Engineers, Office of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C. Department of the Army, May, 1975.

2. Perry, Eugene S., 1962-Montana in the Geologic Past: Montana Bureau of Mines and Geology. Bulletin 26.

3. U.S. Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, 1972.

4. G.J. Wicks, The Framework Report, Montana Department of Natural Resources and Conservation, Water Resources Division, Vol. 1, 1976.

5. Montana Department of Natural Resources and Conservation, "State Water Conservation Projects," March, 1977.

6. National Oceanic and Atmospheric Administration, NOAA Atlas 2, "Precipitation - Frequency Atlas of the Western United States", Volume 1 - Montana, 1973.

7. U.S. Soil Conservation Service, TR #56, "A Guide to Design and Layout of Vegetative Wave Protection for Earth Dam Embankments," 1974.

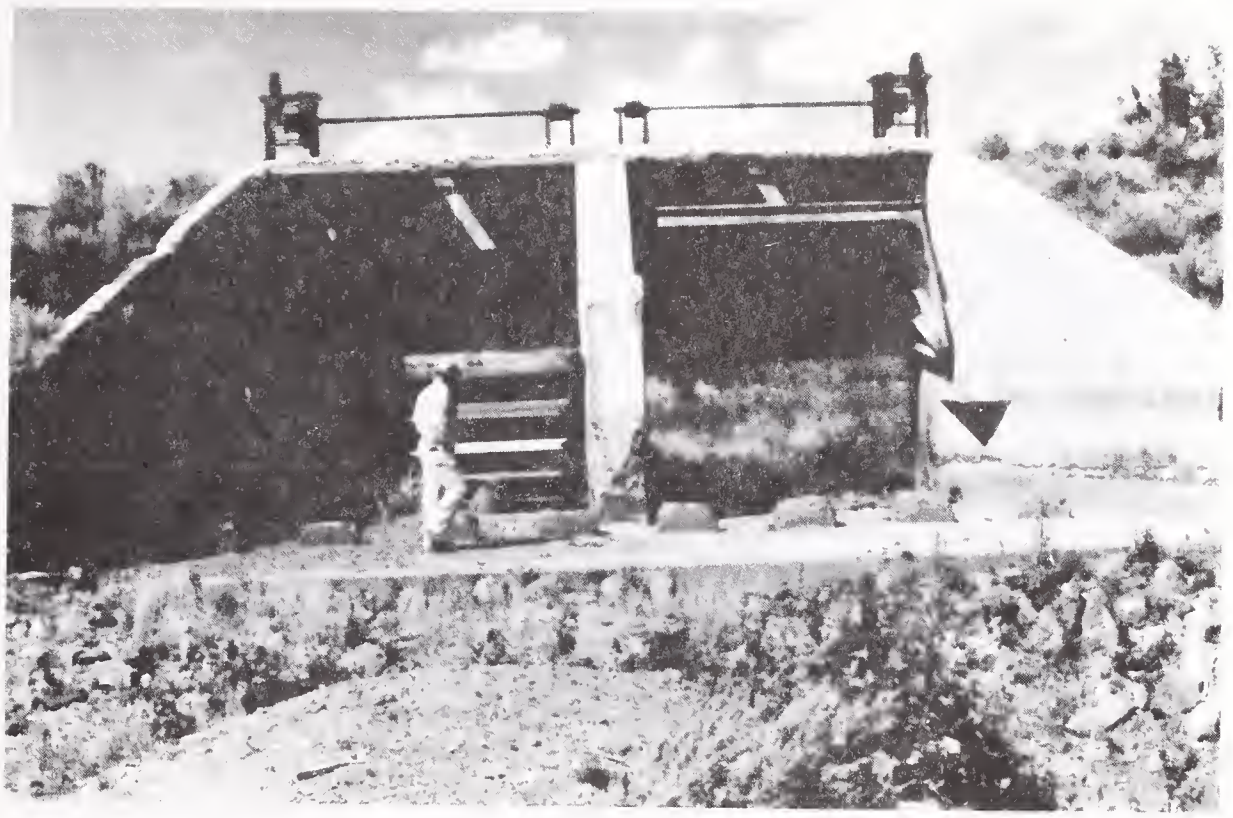


PHOTO 1

Diversion Dam Tainter Gates

PHOTO 2

Supply Canal From Ford's Creek

PHOTO 3

County Bridge Across Canal

Note: Channel Restriction

PHOTO 4

West Dike - Crest and Downstream Slope

Note: White Areas Are Saline Seep

PHOTO 5

West Dike-Upstream Slope

Note: Wave Erosion

PHOTO 6

West Dike-Crest And Upstream Slope

PHOTO 7

Main Dam - Crest Looking North

PHOTO 8

Typical Longtitudinal Crack in Main Dam Crest

PHOTO 9

Main Dam - Downstream Slope

Note: White Saline Areas at Right

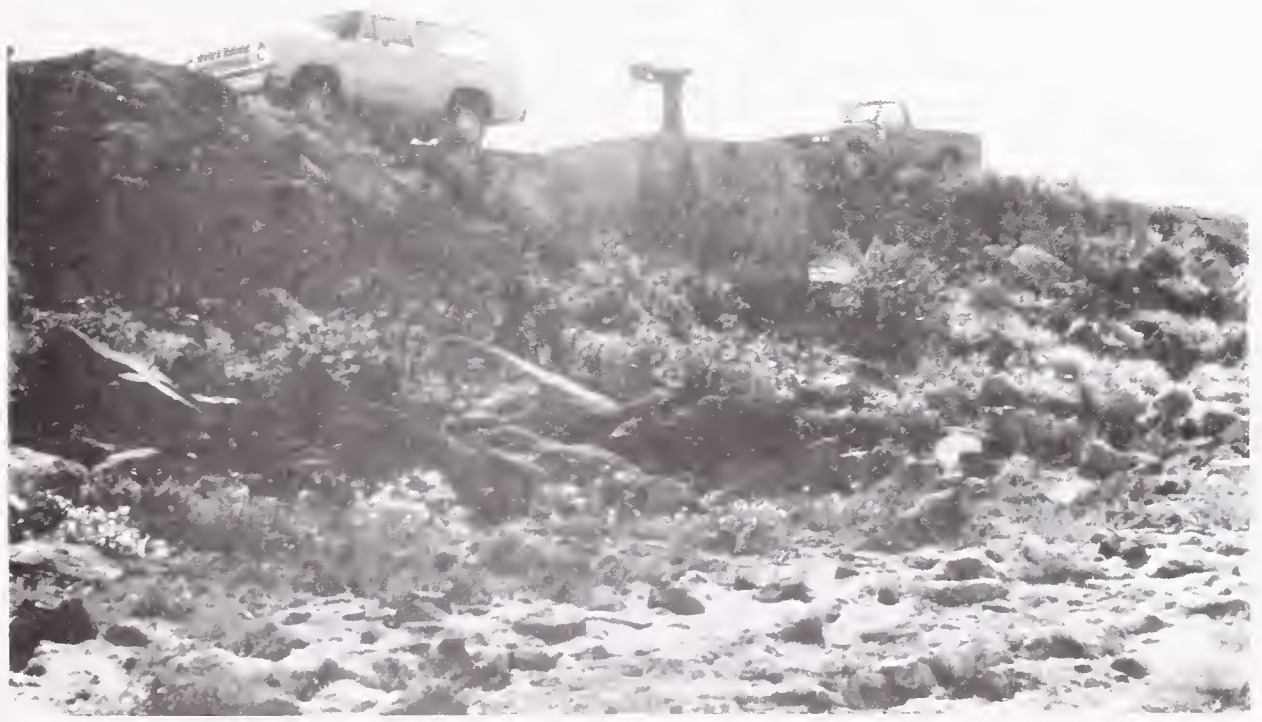


PHOTO 10

Outlet Works Control Tower and Upstream Face

Note: Erosion Behind and Right of Tower

PHOTO 11

Outlet Works Discharge

Note: Deteriorating Concrete

PHOTO 12

Buffalo Creek Supply Canal

PHOTO 13

Emergency Spillway/Canal Breach

Outlined in Black for Clarity

PHOTO 14

Downstream from Emergency Spillway Towards Buffalo Creek

PHOTO 15

MDNRC Photo of 5/79 Wave Erosion-Looking South

PHOTO 16

MDNRC Photo of 5/79 Wave Erosion-Looking North

Note: Water Level at Control Tower At Left,

Also, Compare Crest Width To That In Photo 7

MONTANA

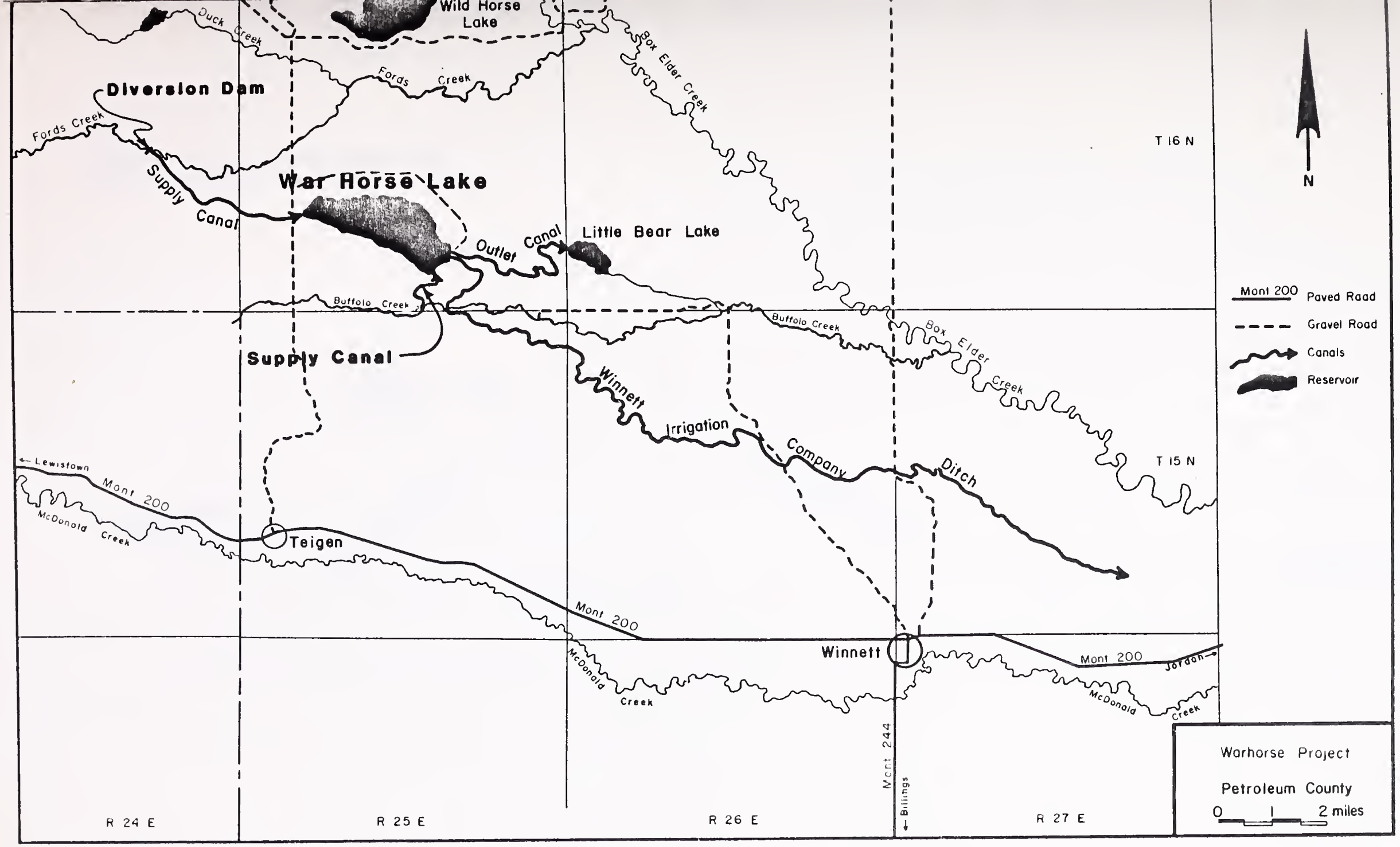
PROJECT LOCATION

# PLATE -1-

## WAR HORSE DAM

## LOCATION MAP

0 20 MILE



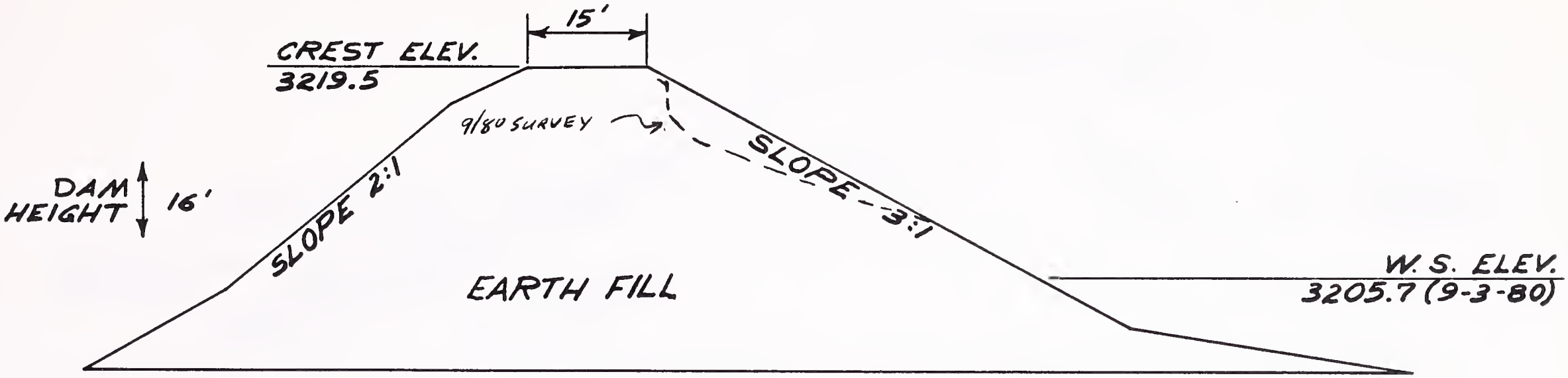

# PLATE -2-

## WAR HORSE DAM

## DRAINAGE MAP

NOTE:

INFORMATION REPRODUCED
FROM WCB PLANS



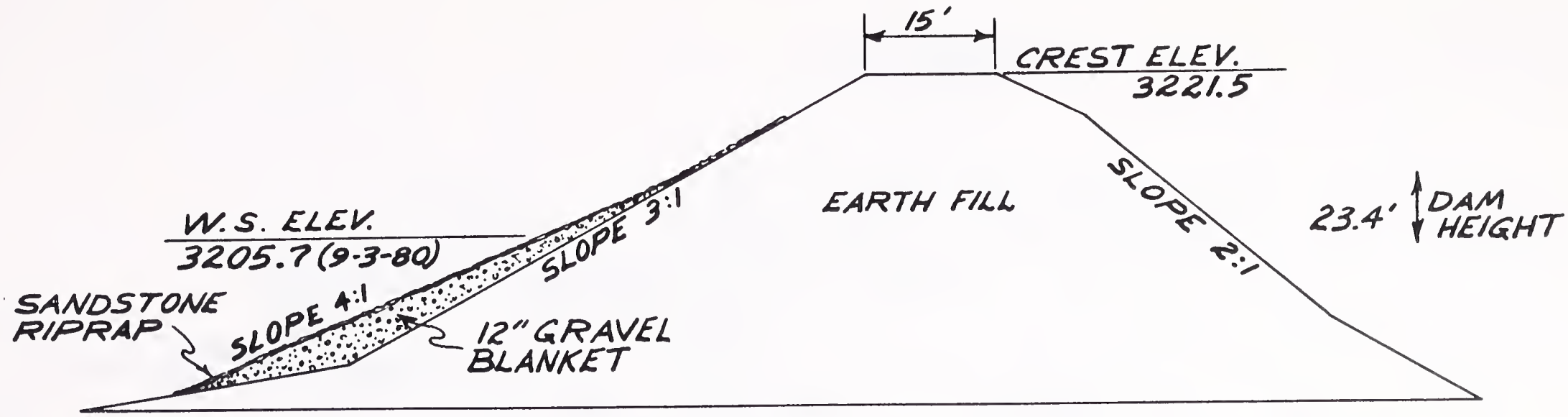

No Scale

# PLATE -3-

## WAR HORSE DAM

## WEST DAM SECTION

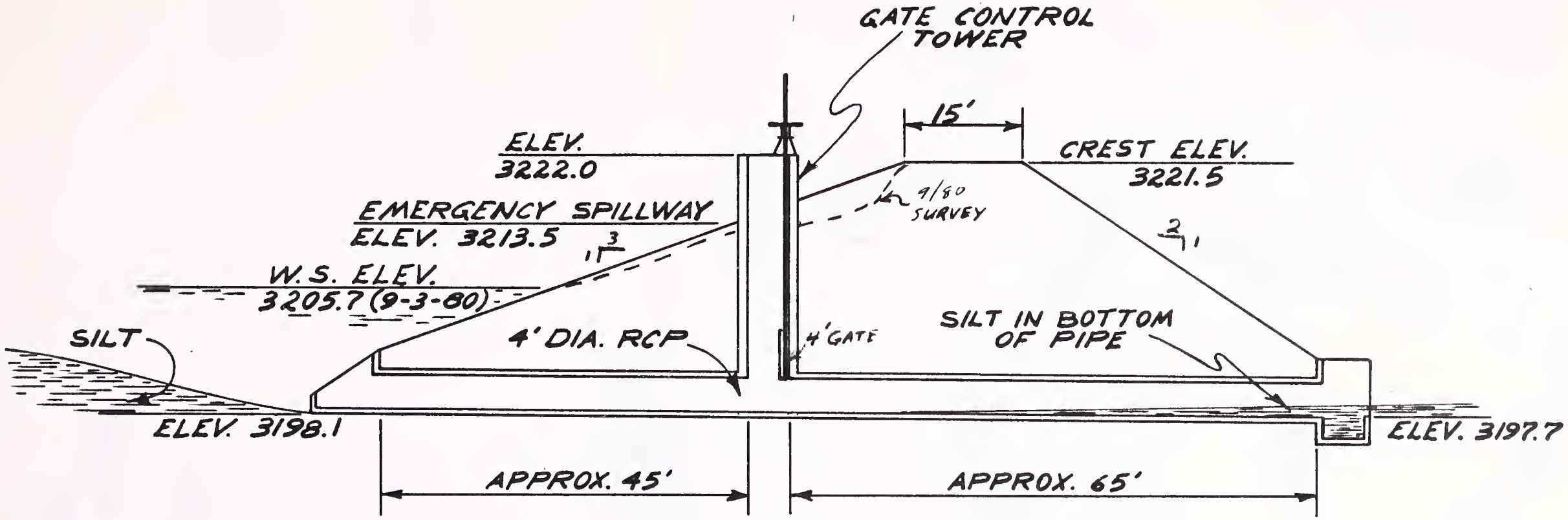
NOTE:
INFORMATION REPRODUCED
FROM WCB PLANS.




NO SCALE

# PLATE -4-

## WAR HORSE DAM
## MAIN DAM SECTION

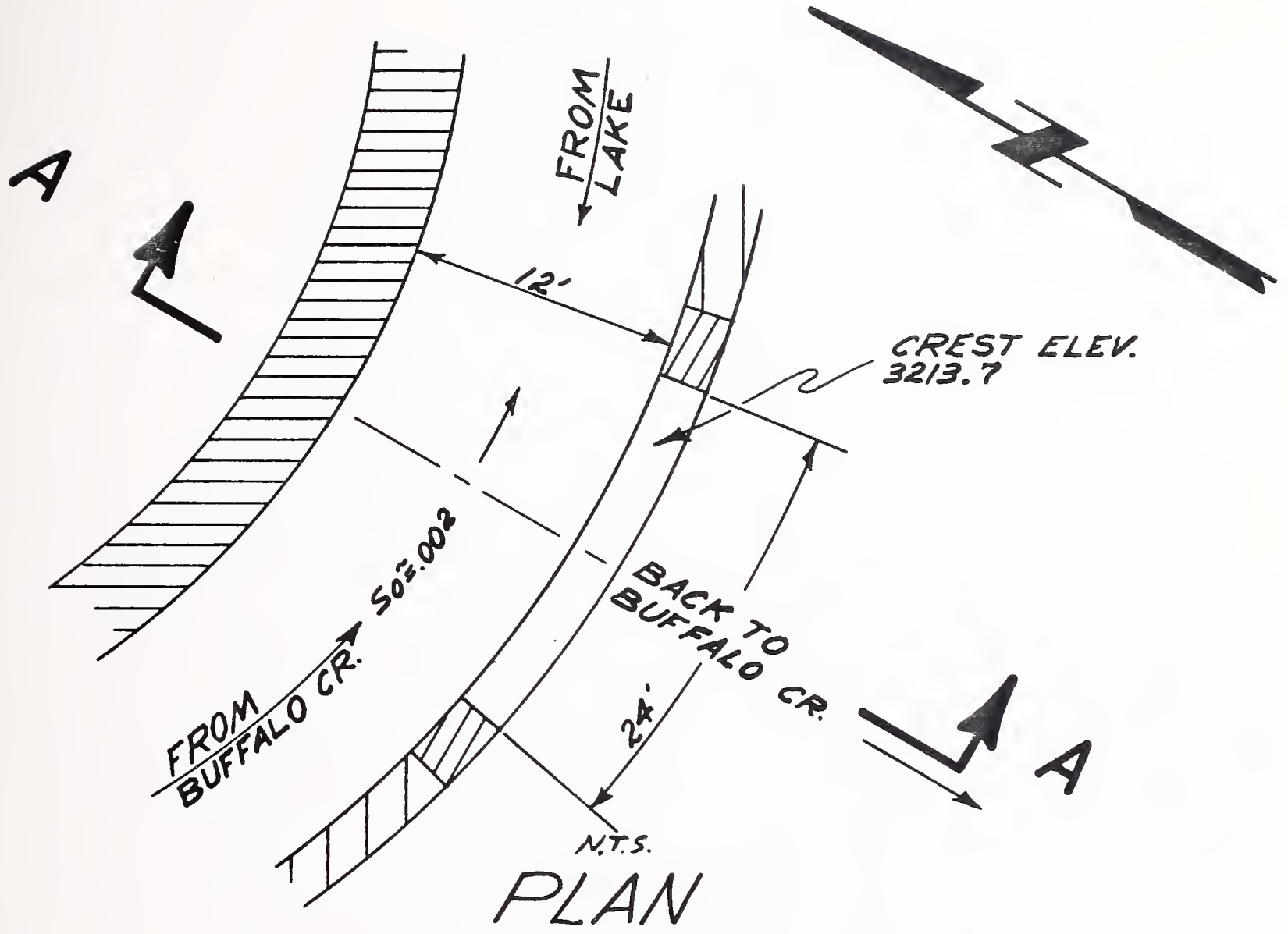



# DAM SECTION AT OUTLET WORKS

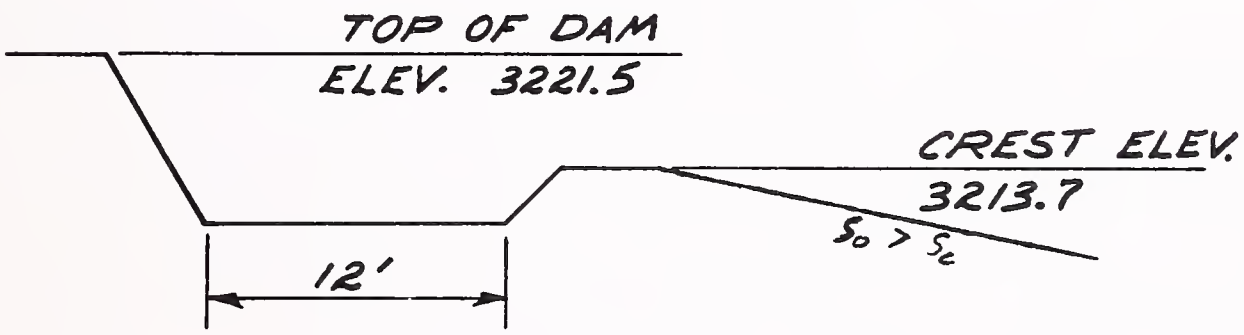
SCALE: 1"=20'

**PLATE -5-**

**WAR HORSE DAM**
**SECTION AT**
**OUTLET WORKS**




PLAN




N.T.S.

SECT. A-A

NOTE:
EMERGENCY SPILLWAY IS BREACHED PORTION OF BUFFALO CREEK SUPPLY CANAL.

# PLATE -6-

## WAR HORSE DAM EMERGENCY SPILLWAY

# APPENDIX A

# WINNETT IRRIGATION COMPANY

Winnett, Montana 59087



June 18, 1981

Department of Natural Resources and Conservation
Att: Glen McDonald, Supervisor - Dam Safety Section
Helena, Montana 59601

Dear Mr. McDonald,

We've read the report and noted several discrepancies that should be corrected.

We don't feel there's any significant danger of loss of life or property..

There is definitely some work that needs to be done but until we have a firm commitment from the Department of Natural Resources for ownership we feel our hands are tied..

Since our reorganization in 1974 we have been doing some maintenance..

Very truly yours,

Vernon Bauer

Vernon Bauer, President

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

TED SCHWINDEN, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872 ADMINISTRATOR
(406) 449-3962 WATER RIGHTS BUREAU
(406) 449-2872 WATER SCIENCES BUREAU
(406) 449-2864 ENGINEERING BUREAU
(406) 449-2872 WATER PLANNING BUREAU

HELENA, MONTANA 59620

June 24, 1981

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Ralph:

Re: Christian, Spring, Sielbach and Associates' Dam Safety Inspection Report on War Horse Dam (MT-13) and War Horse West Dike (MT-3208).

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it satisfies the criteria of the Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Enclosed is a copy of the letter that the Winnett Irrigation Company sent to us with their comments on the inspection report.

Thank you for this opportunity to review and comment on the final draft report on War Horse Dam and War Horse West Dike.

Sincerely,

Glen McDonald

for Richard L. Bondy, P.E.
Chief, Engineering Bureau

RB:AT:lz
enclosure